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A method of checking the validity of earth temperature data

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Records of earth temperatures at a station may become invalid for a number of reasons, for example:-

(a) Poor maintenance

(b) Changes of site within the confines of the station - often only a few metres.

(c) Un-noticed alteration of exposure due to growth of trees, erection of buildings etc.

(d) Un-noticed changes of depth.

If there exists a reliable station in the vicinity which has been correctly maintained over the period in which the records are suspect then a method proposed by Smith[1] and Sarson[2] may be used to check the data.

1. Select a standard period of 10 years, if possible, when both stations were thought to be recording reliable readings.

2. Find the average monthly temperatures at the same depth for both stations during this standard period. Calling the stations A (reliable) and B (suspect) we now have:-

(a) Monthly averages at the "good" station, namely

$\overline{\text{JAN A}}$, $\overline{\text{FEB A}}$ etc

(b) Montly averages at the "suspect" station, namely

$\overline{\text{JAN B}}$, $\overline{\text{FEB B}}$ etc

3. Subtract the B averages from the A averages month by month giving

$$\overline{\text{JAN A}} - \overline{\text{JAN B}} = \bar{\Delta}_1$$

$$\overline{\text{FEB A}} - \overline{\text{FEB B}} = \bar{\Delta}_2$$

" " "

" " "

" " "

$$\overline{\text{DEC A}} - \overline{\text{DEC B}} = \bar{\Delta}_{12}$$

The parameters $\bar{\Delta}_1$ to $\bar{\Delta}_{12}$ are the average monthly differences in earth temperatures between the two stations.

4. Find the monthly mean earth temperatures at the two stations for the whole period during which observations overlap and by subtraction find the monthly actual differences between the two stations giving

/JAN A_1

ORGS UKMO A

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JAN A_1 - JAN B_1 = $_1\Delta_1$

FEB A_1 - FEB B_1 = $_1\Delta_2$

" " "

" " "

" " "

DEC A_N - DEC B_N = $_N\Delta_{12}$

where $_N\Delta_1$ represents the difference for January of the Nth year in the series.

5. On a time base graph, plot, for the whole period (including the standard period of known reliability) the quantities

$\bar{\Delta}_1 = {}_1\Delta_1$; $\bar{\Delta}_2 = {}_1\Delta_2$; . . . $\bar{\Delta}_{12} = {}_1\Delta_{12}$; (1st year)

$\bar{\Delta}_1 = {}_2\Delta_1$; $\bar{\Delta}_2 = {}_2\Delta_2$; . . . $\bar{\Delta}_{12} = {}_2\Delta_{12}$; (2nd year)

" " "

" " "

" " "

$\bar{\Delta}_1 = {}_N\Delta_1$; $\bar{\Delta}_2 = {}_N\Delta_2$; . . . $\bar{\Delta}_{12} = {}_N\Delta_{12}$; (Nth year)

Over the standard period, the curve should show a pattern of random fluctuations probably not exceeding $\pm 0.5^{\circ}C$. If this pattern is not repeated over the rest of the graph then the dissimilar portions will indicate periods when one of the stations (presumably station B) has been recording invalid data.

Departures from the normal random pattern will be of several distinct types.

(a) A regular sinusoidal curve with either summer or winter maxima

(b) An increase in the amplitude of the random variations

(c) An upward or downward shift of the axis of variation either as a gradual trend or a sudden shift.

It will not always be easy, or even possible, to determine the cause or causes of unreliability in any set of data. However a few general points can be made:-

1. Uncut grass will provide an insulating layer leading to too low summer, and too high winter temperatures at shallow depths. The effect at greater depth may well be a slow general cooling. These effects will show in the graph as a sinusoidal curve with summer maximum; at greater depth a slow downward trend often indicates a similar state of affairs.

2. The effects of shading will largely depend on the time and extent of the shading but may again lead to lowering of summer and raising of winter temperatures shown by a sinusoidal variation in the graph.

/3.

3. Changes in depth may lead to an increase in summer temperatures and a decrease in winter ones if the thermometer is at too shallow a depth and vice versa. Again a sinusoidal pattern will be found with summer minima if the thermometers are at too shallow a depth. The effect will be more pronounced at 1 foot than at 4 feet for a given error in depth.

4. A change of site to a different soil profile may result in a pronounced shift in level showing either general warming or cooling (or may not give any change at all).

5. Thermometer defects e.g. a break in the mercury column will result in a general rise in temperature but occasionally the rise may increase as the temperature rises so that a slight sinusoidal variation may be superimposed on an upward shift of the axis.

This method is used to compare earth temperatures at Ross-on-Wye, Cardiff and Long Ashton in Agriculture Memorandum No 340[3] and examples of the resulting curves are given in figures 1 to 3 of that paper. Figure 1 is reproduced here as a general indication of the changes in deviation found over a period of 39 years.

This method can probably be extended to other meteorological elements eg mean air temperature and possibly sunshine. It may not be so readily applicable to mean maximum and minimum temperatures and certainly should not be used for rainfall data.

References

1. SMITH, L P, Final report of WMO Inter-regional seminar on tropical agro-meteorology, Maracay, Venezuela, 15-28.3.1960, pp 32-34.

2. Meteorological Office, London, Averages of earth temperatures for the British Isles 1921-50, M.O. 665, pp 8-9.

3. COCHRANE, J, Earth temperatures at Cardiff, Long Ashton and Ross-on-Wye, Agr. Memo. No 340.

Any comments or suggestions on this paper should be sent to the author.

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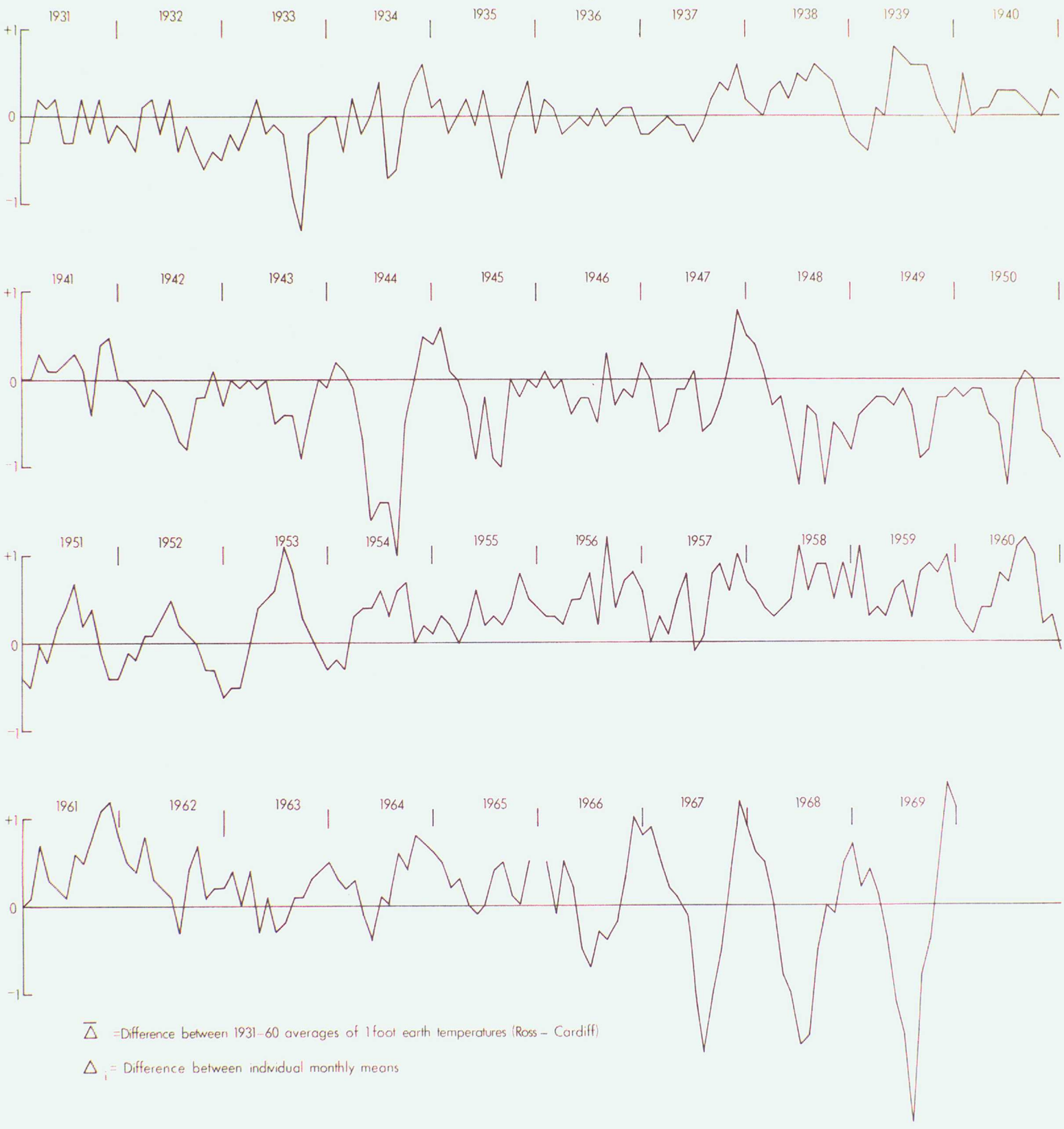
Fig 1 1 foot earth temperature ($\overline{\Delta} - \Delta_i$) ROSS-ON-WYE — CARDIFF



$\overline{\Delta}$ =Difference between 1931–60 averages of 1 foot earth temperatures (Ross – Cardiff)

Δ_i = Difference between individual monthly means